"Uspekhi Matematicheskikh Nauk" Vol. I,
No 3-4 (13-14) 1946

EXPERIMENTAL COMPUTING STATION

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In the Spring of 1943, the Division of Approximate Calculations of the Mathematical Institute of the Academy of Sciences (hereafter designated by MIAN), organized for the first time in the USSR an experimental computing station (eksperimental'naya schetnaya stantsiya), which is equipped with a number of computing apparatus including calculating-analytical machines (schetno-analiticheskaya mashina; hereafter designed by SAM); that is, automatic computing instruments that operate with perforated, or punched, cards or tape.

The perforation principle for directing machines, by means of series of holes prepared beforehand on cards or tape ('perfokart', 'perfolent') is a very old principle of automatization invented by Jacquard in 1804 for the needs of the textile industry (a square, with holes punched beforehand, controls or directs the movement of the needles, which either remain in or slip through the holes, and this movement of the needles determines the interweaving of the fabric). In the second half of the 19th century there appeared, along with such mechanical perforation control, so-called electrical control; for example, in the "automatic" telegraph apparatus of Winston, Murray, etc the text is enciphered in the form of punched holes on a perforated tape (each letter, cipher, etc corresponds to its own series of needles; during the movement of the tape through the receiving ('perceiving') apparatus, at the moment of passage of the perforated hole, the contact acts to give rise to an electric current which transmits a signal to the rec-

giving station). At the end of the 19th century, H. Hollerith was the first to construct a computing apparatus of the perforation type, which is the precursor of the modern SAM. In 1911 Powers constructed mechanical computing punch-card machines that were automatic ('perfo-automat'). In all these instruments the numerical data, same as the signal directions for the machine, is coded by a series of holes punched on punch cards. These machines turned out to be very effective whenever there is a great mass of uniform operations-as in statistics, book-keeping, counting, etc, which warranted their application on a massive scale and compelled designers to work harder on their improvement. The SAM consists of: 1) perforators or punchers-machines for executing perforations on punch cards-the only non-automatic operation; 2) machines for 'logical' operations-sortors that classify punch cards according to the character of the perforations; distributing machines for selection; 3) fundamental computing machines-that sum (tabulators) and multiply (multipliers); these machines can even give responses in the form of perforations on punch cards; 4) a series of auxiliary machines, the most important being the reproducer, which transfers a task in the form of perforations from some cards to others. Every complex mathematical operation can be resolved finally into elementary arithmetrical and logical operations (producible by the SAM) - selection, classification etc and fixation of intermediate answers. Therefore any mathematical operation can, in principle, be conducted on the SAM. We note that tabulators print their own responses ('tabulograms') and some tabulators form these tabulograms so that, in the case of necessity for multipli-

cation (copying) of tables of responses, tabulograms can be multiplied by photo-copying, thus eliminating the difficult process of assembling a table.

In scientific works, calculating-analytical tables have already been employed for a long time in astronomical observatories. They have just begun to appear in general mathematical practice. Meanwhile their prospects here are very good: in numerical solutions of mathematical problems one often encounters the large-scale application of "monotypical" operations that make the SAM a convenient instrument to use; also in the method of grids (method setok: networks, lattices, meshes, nets, etc), identical operations are conducted at all the junctures of the grids; in methods that involve the expansion into series of identical operations one must calculate expansion coefficients; in methods of iteration we proceed by identical operations from each approximation to the following one. Often it is necessary to solve series of identical problems with different values of the initial data or other parameters. Therefore the Division of Approximate Calculations established this as one of the leading problems--namely, the mechanization of the algorithms of numerical solution of mathematical problems with the help of the SAM. We note that methods convenient for "manual" computations can be inconvenient for mechanized computations and vice versa, and this problem is connected with a critical reconsideration of methods used.

We had, in the USSR, first used the SAM in banking organizations, where the first SAM factories arose. In the Credit-Economic Institute within the Gosbank System is the Chair of Mechanized Computation (kafedra mashinizirovannogo scheta) which is headed by Neslukhovskiy; in it once

existed an interesting division of engineer-designers released for work on the SAM (the plan of computations—namely, the setting up of a 'dummy' or 'model' of output punch-cards, directions concerning the construction of the machines, and a plan for the passage of the punch-cards through the machines—was a very difficult task, and one only for skilled personnel). A wider field was assumed by the activity of a special organization of the Trust So[illegible] (All-[illegible] Computing Trust), whose duty is to take on large-scale computational work of various institutions. At the disposal of the Trust in Moscow is a computing factory with 'automatic' and 'manual' shops and with a network of affiliates in various institutions; this factory is working on the results of the all-Union census of 1939. The industrial basis is represented by the SAM factory in Moscow, which made, before the War, punch devices, sorters, tabulators (designs by Engineers Neslukhovskiy, Rozankin, etc) and now other machines.

The pioneers in the application of the SAM to large-scale computations were I. N. Yanzhul, Neslukhovskiy, Ye. Ye. Uspenskiy, Gipodman.

Let us consider awhile the activities of Ivan Nikolayevich Yanzhul. He was the author of our best book on the mechanization of computations. Although mathematics was not his specialty, he possessed a keen intuition in problems of computation and devised a number of clever computing devices, new for his time, for the SAM (for example, to him belongs the methods of finding sums of products on a tabulator). Attracted to the work at the Astronomical Institute at Leningrad, he began to employ the SAM for large-scale astronomical computations (see his article in the "Astronomicheskiy Zhurnal" 1940, No. 5).

At MIAN the co-workers who worked, in contact with I. M. Vinogradov, on the application of the AP were: I. Ya. Akushskiy, on computations for navigational tables; L. Ya. Shnirelman, in 1930-1940; K. A. Semendyayev, on ballistic calculations in 1940-1941. These works of the Astronomical and Mathematical Institutes were conducted within the system of the Soyuzmashuchet (All-Union Machine Computing Trust). It was proposed to construct for both Institutes a general computing station at Leningrad; I. M. Vinogradov introduced several adjustments and devices into the T-4 Tabulator which was ordered at the ÉLA factory for the proposed station. The War prevented the realization of this plan. In Jan 1942, I. M. Vinogradov died in Leningrad at the time of the blockade; our computational mathematics suffered a heavy loss in the person of this talented man.

In 1942-1943 at the time of the evacuation of the Mathematical Institute of the Academy of Sciences to Kazan, the Division of Approximate Calculations of the MIAN was developing computational work at Moscow and renewed its connections with the Soyuzmashuchet by carrying out computations in its 'manual' and 'mechanized' shops. In May 1943, on the initiative of acting director of MIAN for the Moscow group, Prof. A. F. Bermant, an affiliate of the computing factory of the Soyuzmashuchet was organized in the MIAN, namely, a computing station in the MIAN. A large amount of effort in the operation of the computing station was exerted in the beginning by Ye. Ye. Ugenskiy, then one of the directors of the workers at the factory (at present, director of the computing factory at Gidrometeoizdat (Hydrometeorological Service)). The work of starting, developing, and maintaining the activity under the difficult conditions of wartime rested on the Chief of the Industrial

Department of the MIAN (scientific co-worker I. Ya. Akushskiy). The equipment of the station consisted (after several replacements and additions) of two sets of punching devices, sorters and tabulators, multipliers and reproducers, etc. and also a number of 'small machines'-electrical arithmometers. The staff of the station consisted of chief (A. A. Parshikov); engineer-designer (in the beginning, A. I. Trusov); a 'small-machine' mechanic; 'large machine' operators; a variable number (5 to 20) of 'manual' calculators, who conducted computational work together with the junior co-workers of the Division of Approximate Calculations (when large-scale ballistic computations were conducted in the Institute, the number of calculators reached 22 to 24). The larger SAM machines when free from MIAN work were charged with executing the current works of the factory.

On the 'larger machines' were carried out the following works: the calculation of tables for radio direction finding (Akushskiy) and the translation of bispherical coordinates into Cartesian coordinates (by Semendyayev and Akushskiy); the annual; computation of the ephemerids of the Moon and stellar displacements for the astronomical year book, which was connected with the adjustment of the T-4 tabulator for a sexagesimal system (Semendyayev); conduction of numerical solutions of individual equations in mathematical physics by the method of series (the finding of 750 coefficients, of the following form:

$$\int_0^{\infty} f(x) F(x) dx$$

for Flyatter's integrodifferential equation) and by the method of grids (setka); the solution of the Laplacian equation by Libman's method with a large number of angular points and by conditions of discontinuity on the internal contours for problems of thermal exploration (teploraszvedka)

(worked on by Akushskiy); experimental calculations in harmonic analysis, solution of linear difference equations (by Akushskiy) etc.

Under wartime conditions the computing station experienced great difficulties-it was unable to maintain the most up-to-date machines; the greatest difficulties were in the manning of the personnel: for two years the station worked without 'large-machine' mechanics. At the present time we have in the person of A. A. Simonov an expert mechanic, who is taking the initiative in helping the scientific co-workers to conduct complicated experimental works. Recently the station has been supplemented with new machines, more flexible and with great possibilities in the sense of their application to the mechanization of complicated arithmatic (algorithms).

This has permitted us to fulfil the scientific mission of the Division and to include in our plans experimental work on the SAM in regard to harmonic analysis with a large number of ordinates and numerical manipulation of Fourier transformations(transforms), mechanization of the solution of equations involving special functions, and the solution of systems of linear algebraic equations with a large number of unknowns.

At present, a number of scientific organizations have begun to create their own computing stations. They can utilize in their organization and future work the experience gained by the first such station at the MIAN.

A pressing problem is the training of mathematicians who are familiar with planning of work on the SAM (for complicated mathematical works this planning often requires great skill). The Division is preparing a small number of such workers for its own internal needs. On a much wider scale, they must be trained by universities utilizing, for example, our station as a basis for industrial practice.

In the next issue of Uspekhi Matematicheskikh Nauk (Vol I, No 5-6, 1946) a group of articles on mathematical machines will describe the ENIAC and examples of its work and mathematical operations.

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